Name **Period** **Date**

Newton's First Law

Driving Questions

What factors affect the motion of objects? Aristotle (384 BC to 322 BC) believed that the natural state of an object was to be at rest and therefore that all objects in motion will eventually come to a stop. Is this view correct?

What are the causes of changes in motion?

What are the "rules" underlying an object's motion.

Background

There was much argument between early philosophers and scientists regarding the motion of objects. In the 17th century, Sir Isaac Newton formalized his three laws of motion.

The first law of motion: An object will maintain its state of rest or uniform motion unless acted upon by an external unbalanced force.

This became known as the law of inertia.

Newton's first Law indicates that an object traveling with constant velocity will maintain that constant velocity unless otherwise acted upon by a net force. In addition, objects at rest (zero velocity) will stay at rest unless otherwise acted upon by a net force.

In other words, if the net force on an object is zero, its acceleration is also zero. We will investigate this concept by exploring the measured velocities associated with several different types of motion of a cart.

Materials and Equipment

For each student or group:

- Data collection system
- Motion sensor
- Dynamics cart
- Dynamics track with feet
- Dynamics track end stop
- Mass and hanger set
- Super pulley with clamp
- String, ~1 m

Safety

Add this important safety precaution to your normal laboratory procedures:

- Keep water away from any sensitive electronic equipment.

Sequencing Challenge

The steps below are part of the Procedure for this lab activity. They are not in the right order. Determine the proper order and write numbers in the circles that put the steps in the correct sequence.

◯	◯	◯	◯
Measure the velocity of a cart as a hanging mass acts on the cart.	Measure the velocity of a cart at rest on a flat track before setting the cart in motion.	Use velocity data to determine if any net forces are acting on the cart.	Setup the dynamics track with super pulley at one end and the motion detector at the opposite end.

Procedure

After you complete a step (or answer a question), place a check mark in the box (☐) next to that step.

Note: When you see the symbol "�" with a superscripted number following a step, refer to the numbered Tech Tips listed in the Tech Tips appendix that corresponds to your PASCO data collection system. There you will find detailed technical instructions for performing that step. Your teacher will provide you with a copy of the instructions for these operations.

Set Up

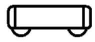
1. ☐ Start a new experiment with your data collection system. �(1.2)

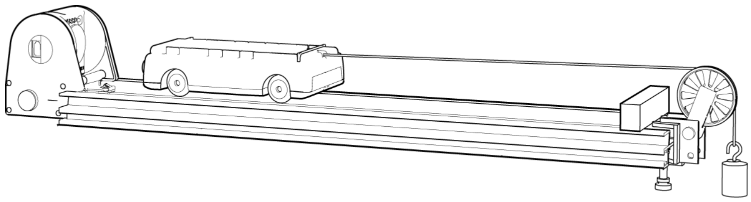
2. ☐ Connect the motion sensor to the data collection system. �(2.1)

3. ☐ Display Velocity on the *y*-axis of a graph with Time on the *x*-axis. �(7.1.1)

4. ☐ Set the dynamics track on the lab table with one end of the track aligned with the edge of the lab table (or slightly hanging over the edge).

5. ☐ Attach the end stop and then the super pulley with clamp to the end of the track near the edge of the table.

6. ☐ Attach the motion sensor to the opposite end of the track with the face of the sensor pointed toward the super pulley. Be sure the switch on the sensor is set to the cart position. 



7. ☐ Connect the motion sensor to your data collection system. �(2.1)

8. ☐ Set the cart onto the track, and then adjust the level of the track using its adjustable feet so that the cart remains stationary when left at rest.

9. ☐ Cut a piece of string approximately 1 m long in preparation for data collection.

10. ☐ What will happen to an object at rest if no force is applied?

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11. ☐ What is required for an object to maintain motion at a constant velocity?

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12. ☐ What will happen to an object if there is a constant net force applied to it?

Collect Data

13. ☐ With the cart stationary in the middle of the track, start data recording. �(6.2)

14. ☐ After approximately 5 seconds, stop data recording. �(6.2)

15. ☐ Now place the dynamics cart on the track approximately 15 cm in front of the motion sensor.

16. ☐ Start data recording. �(6.2)

17. ☐ Give the cart a soft push towards the super pulley, then catch the cart just before it hits the super pulley at the end of the track.

18. ☐ Stop data recording. �(6.2)

19. ☐ For the final data run, tie one end of your 1 m piece of string to the front of the dynamics cart, and tie the other end to the mass hanger.

20. ☐ Run the string over the pulley with the mass hanger hanging freely below the pulley.

21. ☐ Hold the cart in place approximately 15 cm in front of the motion sensor, and then attach 20 g of mass to the hanger. Continue to hold the cart.

22. ☐ Start data recording. �(6.2)

23. ☐ Release the cart, and allow it to freely roll down the track.

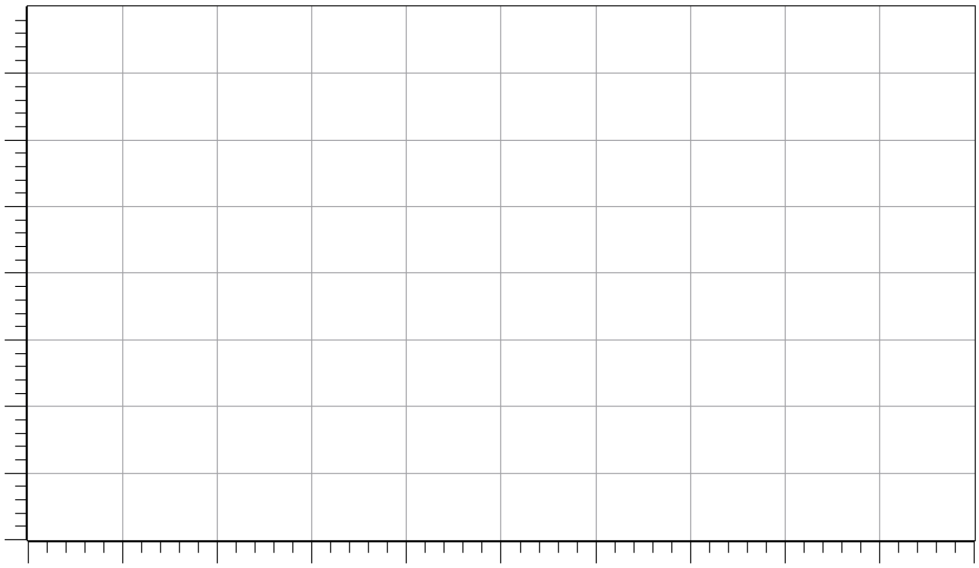
24. ☐ Catch the cart just before it hits the super pulley at the end of the track.

25. ☐ Stop data recording. �(6.2)

Analyze Data

26. ☐ Sketch your graph of Velocity versus Time in the Data Analysis section, and label each run.

Data Analysis



Analysis Questions

1. **How was the velocity of the cart in Run 1 changing? Was there a net force acting on the cart? If yes, what is that force caused by?**

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2. **Explain how you could tell how the cart's position was changing from a Velocity versus Time graph rather than directly from a Position versus Time graph.**

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3. **How was the velocity of the cart in Run 2 changing? Was there a net force acting on the cart? If yes, what was that force caused by?**

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4. **How was the velocity of the cart in Run 3 changing? Was there a net force acting on the cart? If yes, what was that force caused by?**

5. **What evidence from the Velocity versus Time graph for Run #3 indicated there was a net force acting on the cart?**

Synthesis Questions

Use available resources to help you answer the following questions.

1. **What happens to the velocity of an object if it never experiences an unbalanced force?**

2. **How do forces affect the motion of objects? (Think of a force as a push or pull acting on an object.)**

3. **Is it possible for an object to experience a net force without physically touching another object? If yes, give an example.**

4. **An object's resistance to change in motion is called "inertia". What property of matter gives an object inertia? Give an example of something with a relatively large amount of inertia, and something else with a relatively small amount.**

5. What would happen to a ball if you threw it in deep space where there were no forces acting on it? Describe its motion during the time you are in contact with it and then after you release it.

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Multiple Choice Questions

Select the best answer or completion to each of the questions or incomplete statements below.

1. You slide a box across the floor at a constant velocity. Which of the following statements is true?

- **A.** Your pushing force exactly equals the resisting force of friction.
- **B.** Your pushing force must be greater than the force of friction.
- **C.** Your pushing force is less than the force of friction.
- **D.** Once you let go of the box, it will immediately come to a stop.

2. If you continue to push with the same force after the box slides onto a surface with less friction, which of the following statements is true?

- **A.** The box will speed up until it reaches a faster velocity and then continue at that velocity.
- **B.** The box will speed up continuously as long as you continue to push with the same force.
- **C.** The box will continue to slide at its original speed.
- **D.** If you let go of the box it, will continue to move indefinitely.

3. If an object experiences a constant net ___________, it will have a constant_______. However, if no force interacts with an object, that object will maintain a constant __________ indefinitely.

- **A.** Acceleration, force, velocity.
- **B.** Velocity, acceleration, force
- **C.** Force, acceleration, velocity
- **D.** Force, velocity, acceleration

Key Term Challenge

Fill in the blanks from the list of randomly ordered words in the Key Term Challenge Word Bank.

1. _________________ is a term that refers to an object's resistance to a change in motion. Objects that are more _________________ are harder to accelerate. If an object experiences a constant net _________________, it will have a constant _________________. However, if nothing interacts with an object, it will maintain a constant _________________ indefinitely. _________________ is required for an object to maintain a constant speed in a straight line.

Key Term Challenge Word Bank

Paragraph 1

Velocity

Massive

Acceleration

Momentum

Force

Energy

Nothing

Inertia

Displacement